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Contents

1.0 Introduction

1.1 Background

Restoration[1] of contaminated ground waters is one of the primary objectives of both the Superfund and RCRA Corrective Action programs. Ground-water contamination problems are pervasive in both programs; over 85 percent of Superfund National Priorities List (NPL) sites and a substantial portion of RCRA facilities have some degree of ground-water contamination. The Superfund and RCRA Corrective Action programs share the common purposes of protecting human health and the environment from contaminated ground waters and restoring those waters to a quality consistent with their current, or reasonably expected future, uses.

The National Contingency Plan (NCP), which provides the regulatory framework for the Superfund program, states that:

> "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (NCP §300.430(a)(1)(iii)(F)).

Generally, restoration cleanup levels in the Superfund program are established by applicable or relevant and appropriate requirements (ARARs), such as the use of Federal or State standards for drinking water quality. Cleanup levels protective of human health and the environment are identified by EPA where no ARARs for particular contaminants exist (see Section 4.1.1).

The RCRA Corrective Action program for releases from solid waste management facilities (see 40 CFR 264.101)[2] requires a facility owner/operator to:

> "...institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit..."

The goal of protectiveness is further clarified in the Preamble to the Proposed Subpart S to 40 CFR 264:

> "Potentially drinkable ground water would be cleaned up to levels safe for drinking throughout the contaminated plume, regardless of whether the water was in fact being consumed... Alternative levels protective of the environment and safe for other uses could be established for ground water that is not an actual or reasonably expected source of drinking water."[3]

While both programs have had a great deal of success reducing the immediate threats posed by contaminated ground waters, experience over the past decade has shown that restoration to drinking water quality (or more stringent levels where required) may not always be achievable due to the limitations of available remediation technologies (EPA 1989b, 1992d). EPA, therefore, must evaluate whether ground-water restoration at Superfund and RCRA ground-water cleanup sites is attainable from an engineering perspective. **This document outlines EPA's approach to evaluating the technical impracticability of attaining required ground-water cleanup levels and establishing alternative, protective remedial strategies where restoration is determined to be technically impracticable.**

Many factors can inhibit ground-water restoration. These factors may be grouped under three general categories:

- Hydrogeologic factors;
- Contaminant-related factors; and
- Remediation system design inadequacies.

Hydrogeologic limitations to aquifer remediation include conditions such as complex sedimentary deposits; aquifers of very low permeability; certain types of

1 For this guidance, "restoration" refers to the reduction of contaminant concentrations to levels required under the Superfund or RCRA Corrective Action programs. For ground water currently or potentially used for drinking water purposes, these levels may be Maximum Contaminant Levels (MCLs) or non-zero Maximum Contaminant Levels Goals (MCLGs) established under the Safe Drinking Water Act; State MCLs or other cleanup requirements; or risk-based levels for compounds not covered by specific State or Federal MCLs or MCLGs. Other cleanup levels may be appropriate for ground waters used for non-drinking water purposes.

2 At this time, this guidance is not applicable to corrective actions for releases from Subpart F regulated units that are subject to corrective actions under 40 CFR 264.91-264.100.

3 "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities," 55 FR 30798-30884, July 27, 1990, Proposed Rules, is currently used as guidance in the RCRA Corrective Action program. When final regulations under Subpart S are promulgated, certain aspects of this guidance pertaining to the RCRA program may need to be revised to reflect new regulatory requirements.

fractured bedrock; and other conditions that presently make extraction or *in situ* treatment of contaminated ground water extremely difficult (Figure 1).

Contaminant-related factors, while not independent of hydrogeologic constraints, are more directly related to contaminant properties that may limit the success of an extraction or *in situ* treatment process. These properties include a contaminant's potential to become either sorbed onto, or lodged within, the soil or rock comprising the aquifer. Nonaqueous phase liquids (NAPLs) are examples of contaminants that may pose such technical limitations to aquifer restoration efforts. NAPLs that are denser than water (DNAPLs) often are particularly difficult to locate and remove from the subsurface; their ability to sink through the water table and penetrate deeper portions of aquifers is one of the properties that makes them very difficult to remediate (Figure 1).

The widespread use of DNAPLs in manufacturing and many other sectors of the economy prior to the advent of safe waste-management practices has led to their similarly widespread occurrence at ground-water contamination sites. Most of the sites where EPA already has determined that ground-water restoration is technically impracticable have DNAPLs present. The potential impact of DNAPL contamination on attainment of remediation goals is so significant that EPA is developing specific recommendations for DNAPL site management; the key elements of this strategy are presented in Section 3.0 below.

The third factor that may limit ground-water restoration is inadequate remediation system design and implementation. Examples of design inadequacies in a ground-water extraction system include an insufficient number of extraction points (e.g., ground water or vapor extraction wells) or wells whose locations, screened intervals, or pumping rates lead to an inability to capture the plume. Design inadequacies may result from incomplete site characterization, such as inaccurate measurement of hydraulic conductivity of the affected aquifer or not considering the presence of NAPL contamination. Poor remediation system operation, such as excessive downtime or failure to modify or enhance the system to improve performance, also may limit the effectiveness of restoration efforts. **Failure to achieve desired cleanup standards resulting from inadequate system design or operation is not considered by EPA to be a sufficient justification for a determination of technical impracticability of ground-water cleanup.**

1.2 Purpose of the Guidance

This guidance clarifies how EPA will determine whether ground-water restoration is technically impracticable and what alternative measures or actions must be undertaken to ensure that the final remedy is protective of human health and the environment. Topics covered include the types of technical data and analyses needed to support EPA's evaluation of a particular site and the criteria used to make a determination. As technical impracticability (TI) decisions are part of the process of site investigation, remedy selection, remedial action, and evaluation of remedy performance, the guidance also briefly discusses the overall framework for decision making during these phases of site cleanup.

This guidance does not signal a scaling back of EPA's efforts to restore contaminated ground waters at Superfund sites and RCRA facilities. Rather, EPA is promoting the careful and realistic assessment of the technical capabilities at hand to manage risks posed by ground-water contamination. This guidance provides consistent guidelines for evaluating technical impracticability and for maintaining protectiveness at sites where ground water cannot be restored within a reasonable timeframe. EPA will continue to conduct, fund, and encourage research and development in the fields of subsurface assessment, remediation, and pollution prevention so that an ever decreasing number of sites will require the analysis described in this document.

2.0 Ground-Water Remedy Decision Framework

2.1 Use of the Phased Approach

At sites with very complex ground-water contamination problems, it may be difficult to determine whether required cleanup levels are achievable at the time a remedy selection decision must be made. This is especially true when such decisions must be based on site data collected prior to implementation and monitoring of pilot or full-scale remediation systems. EPA recognizes this limitation and has recommended several approaches to reduce uncertainty during the site characterization, remedy selection, and remedy implementation processes (EPA 1989a, 1992a).

Determining the restoration potential of a site may be aided by employing a **phased approach** to site characterization and remediation. Each phase of site

Figure 1. Examples of Factors Affecting Ground-Water Restoration

Certain site characteristics may limit the effectiveness of subsurface remediation. The examples listed below are highly generalized. The particular factor or combination of factors that may critically limit restoration potential will be site specific.

Generalized Remediation Difficulty Scale

Increasing difficulty →

Contaminant Characteristics

Site Use

Nature of Release	Small Volume, Short Duration, Slug Release → Large Volume, Long Duration, Continual Release

Chemical Properties

Biotic/Abiotic Decay Potential	High → Low
Volatility	High → Low
Contaminant Retardation (Sorption) Potential	Low → High

Contaminant Distribution

Contaminant Phase	Aqueous, Gaseous → Sorbed → LNAPLs → DNAPLs
Volume of Contaminated Media	Small → Large
Contaminant Depth	Shallow → Deep

Hydrogeologic Characteristics

Geology

Stratigraphy	Simple Geology, e.g., Planar Bedding → Complex Geology, e.g., Interbedded and Discontinuous Strata
Texture of Unconsolidated Deposits	Sand → Clay
Degree of Heterogeneity	Homogeneous (e.g., well-sorted sand) → Heterogeneous (e.g., interbedded sand and silts, clays, fractured media, karst)

Hydraulics/Flow

Hydraulic conductivity	High (>10^{-2} cm/sec) → Low (< 10^{-4} cm/sec)
Temporal Variation	Little/None → High
Vertical Flow	Little → Large Downward Flow Component

characterization should be designed to provide information necessary for the next phase of characterization. Likewise, site remediation activities can be conducted in phases to achieve interim goals at the outset, while developing a more accurate understanding of the restoration potential of the contaminated aquifer. An example of how this approach might be applied at a site is provided below in Section 4.4.3.

The timing of phased cleanup actions (early, interim, final) should reflect the relative urgency of the action and the degree to which the site has been characterized. Early actions should focus on reducing the risk posed by site contamination (e.g., removal of contamination sources) and may be carried out before detailed site characterization studies have been completed. Interim remedial actions may abate the spread of contamination or limit exposure but do not fully address the final cleanup levels for the site. Interim actions generally will require a greater degree of site characterization than early actions. However, implementation of interim actions still may be appropriate prior to completion of site characterization studies, such as the Remedial Investigation/Feasibility Study (RI/FS) or RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS). Final remedial actions must address the cleanup levels and other remediation requirements for the site and, therefore, must be based on completed characterization reports. Information from early and interim actions also should be factored into these reports and final remedy decisions.

Phasing of activities generally should not delay or prolong site characterization or remediation. In fact, such an approach may accelerate the implementation of interim risk reduction actions and lead more quickly to the development of achievable final remediation levels and strategies. A phased approach should be considered when there is uncertainty regarding the ultimate restoration potential of the site but also a need to quickly control risk of exposure to, or limit further migration of, the contamination.

It is critical that the performance of phased remedial actions (e.g., control of plume migration) be monitored carefully as part of the ongoing effort to characterize the site and assess its restoration potential. Data collection activities during such actions not only should be designed to evaluate performance with respect to the action's specific objectives but also contribute to the overall understanding of the site. In this manner, actions implemented early in the site remediation process can achieve significant risk reduction and lead to development of technically sound, final remedy decisions.

2.2 Documenting Ground-Water Remedy Decisions Under CERCLA

The phased approach to site characterization and remediation can be employed using the existing decision document options within the Superfund program.

2.2.1 Removal Actions

Removal authority can be used for early actions as part of a phased approach to ground-water cleanup and decision making and should be considered where early response to ground-water contamination is advantageous or necessary. Within the context of ground-water actions, removals are appropriate where contamination poses an actual or potential threat to drinking water supplies or threatens sensitive ecosystems. Examples of actions that might qualify for use of removal authority include removal of surface sources (e.g., drums or highly contaminated soils), removal of subsurface sources (e.g., NAPL accumulations, highly contaminated soils, or other buried waste), and containment of migrating ground-water contamination "hot spots" (zones of high contaminant concentration) or plumes to protect current or potential drinking water supplies.

Removals of subsurface sources most likely will be non-time-critical actions, although time-critical actions may be appropriate for removal of NAPL accumulations or other sources, depending on the urgency of the threat. Documentation requirements for removal actions include a Removal Action Memorandum and, for non-time critical actions, an Engineering Evaluation/Cost Analysis report.[4]

Removal actions must attain ARARs to the extent practicable, considering the exigencies of the situation. The urgency of the situation and the scope of the removal action may be considered when determining the practicability of attaining ARARs (NCP §300.415(i)). Standards or regulations typically used to establish ground-water cleanup levels for final actions (e.g., MCLs/MCLGs) may not be ARARs, depending on the scope of the removal. Further

4 See "Guidance on Conducting Non-Time Critical Removal Actions under CERCLA," OSWER Publication 9360.0-32, August 1993 (EPA 1993b).